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Stabilization Model Building of Management-Research for Requirement Definition Streamlining in ITSC Management

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Abstract

Requirements definition that is an important work process for a project and may determine the success or failure of system development project tends to draw an ambiguous conclusion, which will lead directly to the failure of such a system construction. We think the destabilizing factors that introduce ambiguity into the requirements definition process and, as a result, cause requirements definition projects to fail are factors due to requirements definition methods, factors due to undefined implicit requirements, and factors due to interpersonal relationships among stakeholders. We will analyze requirements definition projects' "destabilizing factors" that destabilize the requirements definition process and result in requirements definition failures as well as failure of IT System Construction (hereinafter referred to as ITSC) as a whole, then we will use fuzzy logic to model this. Additionally, using examples of actual ITSC requirements definition projects, we will apply our model to the situations of a project that concluded successfully and a project that ended in failure, then consider the cause and effect relationship between destabilizing factors and the success and failure of requirements definition projects.

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Keywords: Stability of management,requirements definition, destabilizing factors, stability potential, fuzzy logic

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1. Introduction

1.1. Background of Study

The role of information system has increased its importance, so that the information system is indispensable for the companies to carry out work. Further, the information system has been surely considered as not only a useful product in the companies but also a significant infrastructure in the whole society. As the social mechanism has grown more sophisticated, the information system infrastructure has also continued to become more complicated and the difficulty of introducing it has increased steadily.

Since requirements definition is a major factor in the success of information systems construction, the level of stability at which it can be implemented is a factor connected to the success of ITSC projects as a whole.

1.2. Purpose of Study

The purpose of our research is to model the stability of the ITSC project requirements definition process, apply the results of requirements definition processes from actual ITSC projects, and consider stabilization models as well as requirements definition success and failure

2. Difficulty OF Executing ITSC

2.1. Actual Condition of Information System Construction

The information technology system construction (ITSC) project that regards software creation as the main work is difficult to meet the needs and demands of customers through the quality, cost and delivery. Approx. 70% of all ITSC projects had a problem with the quality, cost or delivery [2]. In addition, the survey results indicate that approx. 18% of all constructed IT systems have not been used actually even after these projects were completed to execute, or other projects were interrupted before the completion of them [3].

The requirements definition that belongs to the upper process in the ITSC plays a role to compile vague requirements from stakeholders into the drawings and documents including the designable content for system installation from the viewpoint of technology, operation and expense. In other words, the requirements definition is an essential process to access the system development life cycle (SDLC), which is related to the following processes (from design process to operation/maintenance process) in the ITSC, and to affect decisively the quality, cost and delivery of the ITSC project. It seems that a request for change abovementioned is submitted because the requirements are decided unclearly in the requirements definition and there is a gap between such requirements and the essentially needed ones. Many causes of project failure arise from the method of executing the requirements definition and its results. Especially, an occurrence of trouble caused by the existence of tacit requirements and ambiguous consensus building that are not expressed clearly leads directly to the project failure under the limited man-hours and time for the requirements definition process.

2.2. Difficulty of executing requirements definition causing its ambiguity

It is evident that the requirements definition for the ITSC is carried out through communication between human beings which accounts for a very large percentage of the requirements definition [4-5]. The ITSC including many distributed cooperative projects increases its difficulty level especially due to communication problems [6].

Since the information technology system is usually equipped with massive functions, all functions of this system to be constructed are generally defined. However, it is necessary to design even the parts or components with undefined requirements to install them in the following processes and also, these undefined requirements are treated as tacit ones. The tacit requirements are often admitted in accordance with each stakeholder's "common sense", which brings a major cause of ambiguity of requirements definition (a gap between requirements).

The stakeholders who have really different backgrounds socially and economically take part in the requirements definition, the interests exist between the stakeholders, individual requirements of the stakeholders intertwine with

their acknowledgement and thoughts on the project, and the requirements definition finishes without enabling the stakeholders to hold those in common. In this case, the stakeholders agree with one another in the style of "scrambling for the pie". Once a trouble occurs, however, the stakeholders consider excessively their interests and requirements and negotiate ineffectively with one another for solution to the problem, so that it will cause a serious problem that affects the quality, cost and delivery of the ITSC project.

3. Presentation of Hypothesis and Research Questions

3.1. Hypothesis

Many factors that destabilize requirements definition are present in requirements definition projects. There is a cause and effect relationship between destabilizing factors and the success and failure of requirements definition. Projects that fail have high instability due to destabilizing factors as well as insufficient stabilizing factors to deal with destabilizing factors; they end up failing because they continue to "waver" with requirements definition projects in a state of instability.

3.2. Research Questions

A. Model destabilizing factors and stabilizing factors in the ITSC project requirements definition process

B. Using one successful and one failed ITSC project requirements definition project as examples, conduct analysis of the states of destabilizing factors and consider the cause and effect relationship between destabilizing/stabilizing factors and the success and failure of projects.

4. Logical Framework

The logical framework for considering modeling of the stability of the requirements definition process is as follows:

4.1. Methods for analyzing and categorizing requirements definition projects' stabilizing factors and stability potential factors

- Assess the success or failure of a requirements definition project using QCD scoring.
- Extract requirements definition projects' destabilizing factors and stabilizing factors from our research and that of others.
- To increase assessment accuracy, weight factors according to their influence on requirements definition with the following rules.

4.2. Method for assigning scores to states of stabilization

- According to the circumstances/state of the requirements definition project in the example, assign a score from 0 to 1 to destabilizing factors and stability potential using fuzzy logic (Table 1).

Table 1: Weighting the level of influence of destabilizing and stabilizing factors

Weight	Score	Rule for assessment
"A"	1.0	Large influence on execution of requirements definition
"B"	0.8	Medium influence on execution of requirements definition
"C"	0.5	Small influence on execution of requirements definition

4.3. Membership functions for defining fuzzy functions

Membership functions for defining fuzzy functions for analysis of destabilizing factors and stability potential in requirements definitions Initially the occurrence of instability of (1) although the effect of the project is small, the impact increases from the middle generation of (2)For this reason, it fits the Logistics function of the following as a membership function. (3)If exceeding a certain limit, the project becomes unstable all at once (=with a critical mass value: critical mass theory)[7-9].

The same form is expected even with possible stable factors to counter destabilization. We think the same applies to the stability possibility (Figure 1).

dx / dt = (a - bx) x (a> 0, b> 0))、F(t)=1/(1+ce-at).

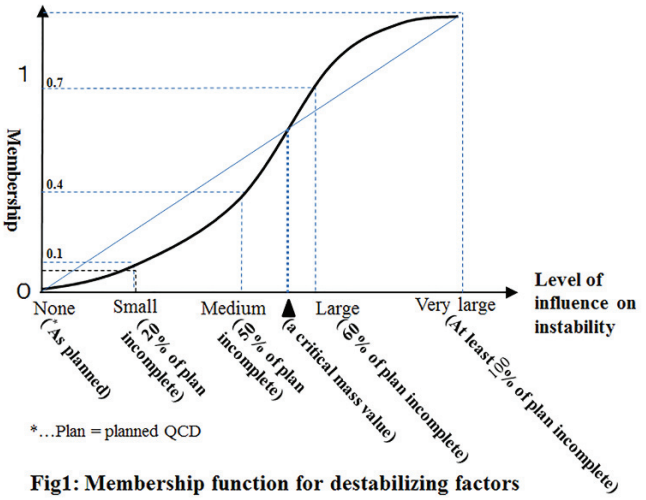

Fig1: Membership function for destabilizing factors

4.4. Assessment method

- Calculate the requirements definition project's level of instability (after assessment of stability potential) by multiplying the weighted average of the stability potential assessment by the destabilizing factor value and subtracting it from the destabilizing factor value.
- Using destabilizing factor values (after assessment of stability potential) and QCD scores to assess a project's success or failure, consider the cause and effect relationship between a requirements definition project's level of instability and its success or failure.

5. Review of Previous Studies

5.1. Requirements definition of efficiency research

A lot of researchers have studied the requirements definition process from the viewpoint of support for capturing the requirements through a meeting, interview or communication, adjustment and negotiation between stakeholders.

K. Doi et al. [10] have developed the user-oriented system planning (USP) method as a requirements capturing method to refine the user's requirements in a meeting and collect all requirements for the developers. In the USP method, the statement, proposal, discussion, question and negotiation are used as communication tools to refine the requirements in a "meeting" of high interaction between user and developer, and the support method (on-line method) and the analysis method in a meeting (off-line method) are applied to hold a smooth meeting. They have also proposed that the quality and quantity of requirements should be refined by using in turn the on-line and off-line methods.

A. Osada et al. [11] have studied a metamodel for presenting the domain characteristics in requirements and their correlations and a model construction method for the specific domain by using documents about existing software systems in order to carry out the requirements definition without contradiction (specification creation) in consideration of correlations between requirements. This study shows a model construction method and a case study for confirming the usefulness of such a method and the points to be improved.

5.2. Study on Optimization of Requirements Definition (Study on Trust Management in Requirements Definition)

Kiritani[12-13]designed, as a model of trust management in the requirements definition, its improved model that the effective optimization of the requirements definition can be expected to enhance communication and negotiation that are the great two factors in the requirements definition process through the development of trust relationships between the stakeholders.

A. Communication efficiency that is improved by the development of trust relationships minimizing the gap between requirements

The improvement of efficiency and accuracy of communication, which depends on the stakeholders, or human beings, through the establishment of mutual trust relationship minimizes the gap between requirements caused by their knowledge and recognition.

B. Realization of effective negotiation process with the development of trust relationships

Because the ITSC is limited by the quality, cost and delivery, it is difficult for the stakeholders to agree with one another after all requirements are defined in the requirements definition process to remove completely the gap recognition between the stakeholders. A technique to allow the effective negotiation process to be performed in order to cope with the problem caused in the following processes is required by mutual agreement on the assumption that there is the representative requirements gap including the tacit requirements.

6. Modeling Destabilizing Factors/Stability Potential

6.1. Modeling destabilizing factors

Our analysis of factors that make ITSC projects “unstable” is in Table 2.

Table 2: Refinement and weighting of destabilizing factors

	Destabilizing phenomenon	Destabilizing factor	Weight
Destabilizing factors due to methods	1. Ambiguity of deliverables	1-1. Definition using polysemic words	B(0.8)
		1-2. Insufficient information from explanations using words	A(1.0)
		1-3. Difficulty of getting across nuance and between-the-lines communication	C(0.5)
	2. Ambiguity of requirements definition methods	2-1. Definition through interpersonal conversation	C(0.5)
		2-2. Occurrence of inconsistent communication	B(0.8)
	3. Ambiguity of contract/job scope	3-1. Ambiguity of job scope	A(1.0)
		3-2. Ambiguity of contract scope	B(0.8)
Destabilizing factors due to the undefined	4. Not all requirements can be defined	4-1. Existence of undefined requirements	A(1.0)
		4-2. Assumption that something is defined	C(0.5)
Destabilizing factors due to interpersonal relationships	5. Ambiguity of consensus building	5-1. Ambiguity in the procedures for consensus building	A(1.0)
		5-2. Treatment of “emotions” in consensus building (individual and group preferences) [15]	C(0.5)
	6. Existence of diverse parties with conflicts of interest	6-1. Acute conflicts of interest	C(0.5)
		6-2. Existence of parties with diverse interests	B(0.8)
		6-3. State of fighting over pieces of the pie among shareholders	C(0.5)

The result is that they were divided into 3 categories: “destabilizing factors due to methods”, “destabilizing factors due to the undefined”, and “destabilizing factors due to interpersonal relationships”. We have also weighted the influence of each factor on the “instability” of requirements definition.

6.2. Modeling of factors (stability potential) that stabilize destabilizing factors in requirements definition

To make clear the stability potential factors acting on destabilizing factors in the requirements definition process, we organized and modeled destabilizing factors and their causes as well as stabilizing components used as responses.

Analysis of the stabilizing factors that stabilize the 3 types of destabilizing factors—"destabilizing factors due to methods", "destabilizing factors due to the undefined", and "destabilizing factors due to interpersonal relationships"—can be found in Table 3.

Table 3: Refinement and weighting of stabilizing factors

Destabilizing factors		Stabilizing factors	Weight
Destabilizing factors due to methods	1. Ambiguity of deliverables, polysemy of words	1-1. Description methods that eliminate ambiguity (usage of shared dictionaries defining words' meanings, etc.)	C(0.5)
		1-2. Greater ease of understanding and increased amount of information by using charts and diagrams	B(0.8)
		1-3. Equalization of backgrounds for nuance and understanding…	C(0.5)
	2. Ambiguity of the requirements definition method	2-1. Preparation of communication rules (meeting structures, contact rules, writing formats)	B(0.8)
		2-2. Increasing communication efficiency (creating relations, utilizing nonverbal communication)	C(0.5)
	3. Ambiguity of contract/job scope	3-1. Making job scopes/job definitions and divisions of roles clear	B(0.8)
		3-2. Making contract scopes clear and refining them and implementing contracts	C(0.5)
Destabilizing factors due to the undefined	4. Not all requirements can be defined	4-1. Making the scope of requirements definitions clear and refining them (making subjects of requirements definitions clear)	B(0.8)
		4-2. Policies to minimize implicit requirements (management of requirements definition levels)	C(0.5)
		4-3. Establishment of tenets for handling discoveries of implicit requirements (problem-solving format), making contract requirements clear	A(1.0)
Destabilizing factors due to interpersonal relationships	5. Ambiguity of consensus building	5-1. Procedures and rules for consensus building	B(0.8)
		5-2. Treatment of "emotions" in consensus building… individual and group preferences	B(0.8)
	6. Existence of diverse parties with conflicts of interest	6-1. Forming levels of intimacy and sympathy	B(0.8)
		6-2. Forming recognition as a business partner	C(0.5)
		6-3. Adoption of a problem-solving format approach to conflicts of interest	A(1.0)

We have weighted the level of influence of each of the factors on "stabilizing factors". "destabilizing factors due to interpersonal relationships" can become impediments to idea reconciliation.

7. Analysis of Destabilizing Factors and Stabilizing Factors in Requirements Definition (Model Validation using Examples)

7.1. States of the ITSC requirements definition projects that were analyzed

The states of actual ITSC Projects A and B are presented in Table 4.

Table 4 .Rough estimate of projects and QCD assessment scores

Properties	Project A			Project B		
1. Name of the ordering side	Company A: Electrical engineering company			Company B: Medical supplies procurement agency		
2. Project contents	Multiple functions including the engineering control function as a main one are added to the basic system for reconstruction.			Full replacement of basic system + Addition of new service function		
3. Construction system contents	Control functions of order reception, engineering, cost accounting, labor, materials and account			Sales management, distribution management and in-hospital service		
4. Scale (No. of all construction processes)	900 persons per month			1,000 persons per month		
5. Master schedule	October 2013 to March 2016			November 2013 to March 2016		
6. Requirements definition schedule	January to the end of June, 2014			June to September, 2014		
7. Inquiring survey date	June 20, 2014			October 10, 2014		
8. Project conditions at inquiring survey date	Performing of business requirements definition and system requirements definition.It will be completed up to the end of June, 2014 according to the schedule.At present, estimating of the next developing processes. Checking of the necessity of coping with them in the priority order.			Completion of business requirements definition investigation. After the confirmation of the results of investigation, careful examining of the whole rough estimate to get a budget.		
9. Inquiring survey parameters	The ordering side: 4	The order-received side: 14		The ordering side: 22	The order-received side: 10	
10. External assessment of requirements definition execution (QCD assessment score)	Quite smooth. Running under the system integrator initiative in agreement. There is no large trouble in tasks.			The requirements definition is one month late. There are many claims and dissatisfactions from the members of the ordering side against the results of investigation. The system integrator side runs over the cost.		
*1: QCD SCORE Each 5-point scale. 5 points is GOOD.	Q (Quality)	C (Cost)	D (Delivery)	Q (Quality)	C (Cost)	D (Delivery)
	8 claims	Under the estimated cost	On delivery	32 claims	Over 18%	34% late
	4*1	5	5	2	3	1
	Can be evaluated as a successful project			Can be evaluated as an unsuccessful project		

7.2. Analysis of destabilizing factors in the requirements definition process of ITSC projects

Analysis of destabilizing factors in Project A and B's requirements definition processes was carried out using fuzzy set values (Table 5).

Table 5: Analysis/organization of actual projects' destabilizing factors using fuzzy logic

				Influence on destabilization (estimated value using fuzzy sets) "1": Very large / "0.7": Somewhat large / "0.4": Somewhat small / "0.1": Very small / "0": Nonexistent					
Category	Destabilizing phenomenon	Destabilizing factor	Weight	Influence on ITSC destabilization (fuzzy sets)					
				Project A			Project B		
				Score	Factor total	Category total	Score	Factor total	Category total
Destabilizing factors due to methods	1. Ambiguity of deliverables	1-1. Definition using polysemic words	B(0.8)	0.4	0.32	0.36	0.4	0.32	0.53
		1-2. Insufficient information from explanations using words	A(1.0)	0.4	0.40		0.4	0.40	
		1-3. Difficulty of getting across nuance and between-the-lines communication	C(0.5)	0.7	0.35		0.7	0.35	
	2. Ambiguity of requirements definition methods	2-1. Definition through interpersonal conversation	C(0.5)	0.4	0.20		0.4	0.20	
		2-2. Occurrence of inconsistent communication	B(0.8)	0.7	0.56		0.7	0.56	
	3. Ambiguity of contract/job scope	3-1. Ambiguity of job scope	A(1.0)	0.4	0.40		0.4	0.40	
		3-2. Ambiguity of contract scope	B(0.8)	0.4	0.32		0.7	0.56	
Destabilizing factors due to the undefined	4. Not all requirements can be defined	4-1. Existence of undefined requirements	A(1.0)	0.7	0.70	0.53	0.7	0.70	0.60
		4-2. Assumption that something is defined	C(0.5)	0.7	0.35		1.0	0.50	
Destabilizing factors due to interpersonal relationships	5. Ambiguity of consensus building	5-1. Ambiguity in the procedures for consensus building	A(1.0)	0.4	0.40	0.21	0.7	0.70	0.49
		5-2. Treatment of "emotions" in consensus building (individual and group preferences) [15]	C(0.5)	0.1	0.05		1.0	0.50	
	6. Existence of diverse parties with conflicts of interest	6-1. Acute conflicts of interest	C(0.5)	0.4	0.20		0.7	0.35	
		6-2. Existence of parties with diverse interests	B(0.8)	0.1	0.08		0.7	0.56	
		6-3. State of fighting over pieces of the pie among shareholders	C(0.5)	0.1	0.05		0.7	0.35	

7.3. Analysis of stabilizing potential factors in the requirements definition process of ITSC projects

Analysis of stabilizing potential factors in Project A and B's requirements definition processes was carried out using fuzzy set values (Table 6).

Table 6: Analysis/organization of actual projects' stabilizing potential using fuzzy logic

				Potential for stabilization (estimated value using fuzzy sets) "1": Very large / "0.7": Somewhat large / "0.4": Somewhat small / "0.1": Very small / "0": Nonexistent					
Category	Destabilizing factors	Stabilizing factors	Weight	Influence on ITSC stabilization (fuzzy sets)					
				Project A			Project B		
				Score	Factor total	Category total	Score	Factor total	Category total
stabilizing factors related to methods	1. Ambiguity of deliverables, polysemy of words	1-1. Description methods that eliminate ambiguity (usage of shared dictionaries defining words' meanings, etc.)	C(0.5)	0.7	0.35	0.47	0.7	0.35	0.43
		1-2. Greater ease of understanding and increased amount of information by using charts and diagrams	B(0.8)	0.7	0.56		0.7	0.56	
		1-3. Equalization of backgrounds for nuance and understanding…	C(0.5)	0.7	0.35		0.4	0.20	
	2. Ambiguity of the requirements definition method	2-1. Preparation of communication rules (meeting structures, contact rules, writing formats)	B(0.8)	0.7	0.56		0.7	0.56	
		2-2. Increasing communication efficiency (creating relations, utilizing nonverbal communication)	C(0.5)	0.7	0.35		0.4	0.20	
	3. Ambiguity of contract/job scope	3-1. Making job scopes/job definitions and divisions of roles clear	B(0.8)	0.7	0.56		0.7	0.56	
		3-2. Making contract scopes clear and refining them and implementing contracts	B(0.8)	0.7	0.56		0.7	0.56	
stabilizing factors related to the undefined. Responses	4. Not all requirements can be defined	4-1. Making the scope of requirements definitions clear and refining them (making subjects of requirements definitions clear)	B(0.8)	0.7	0.56	0.57	0.7	0.56	0.44
		4-2. Policies to minimize implicit requirements (management of requirements definition levels)	C(0.5)	0.7	0.35		0.7	0.35	
		4-3. Establishment of tenets for handling discoveries of implicit requirements (problem-solving format), making contract requirements clear	A(1.0)	1.0	0.80		0.4	0.40	
stabilization potential related to interpersonal relationships	5. Ambiguity of consensus building	5-1. Procedures and rules for consensus building	B(0.8)	1.0	0.80	0.67	0.4	0.32	0.31
		5-2. Treatment of "emotions" in consensus building… individual and group preferences	B(0.8)	0.7	0.56		0.4	0.32	
	6. Existence of diverse parties with conflicts of interest	6-1. Forming levels of intimacy and sympathy	B(0.8)	1.0	0.80		0.4	0.32	
		6-2. Forming recognition as a business partner	C(0.5)	1.0	0.50		0.4	0.20	
		6-3. Adoption of a problem-solving format approach to conflicts of interest	A(1.0)	0.7	0.70		0.4	0.40	

8. Observations

8.1. Analysis of stabilization potential for destabilizing factors in the definition process of ITSC projects

A. Regarding destabilizing factors

In Fig.2, where destabilizing factors in the requirements definition process of actual projects are compared, Project A's destabilizing factors are small on all axes of assessment. Additionally, in both projects, one can see a trend towards strong destabilizing factors due to the undefined. Project A has especially weak destabilizing factors resulting from interpersonal relationships. It can be inferred that this is because building of interpersonal relationships has already occurred through past transactions and results.

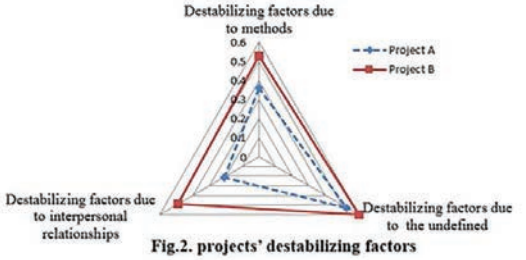

Fig.2. projects' destabilizing factors

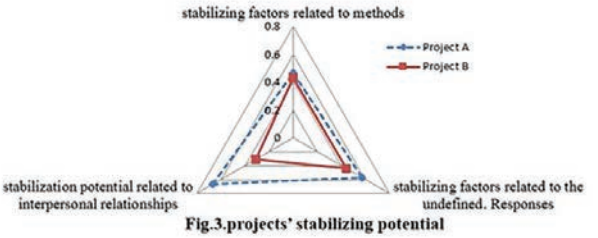

Fig.3.projects' stabilizing potential

B. Regarding stabilizing potential factors

For stabilizing potential, both projects A and B have high scores for stabilizing factors related to methods as well as stabilizing factors related to the undefined (Fig.3). Responses to methods and the undefined can become problems for procedures and plans; we predict that following procedures and plans will stabilize the project regardless of other instability levels.

Project B's stabilization potential related to interpersonal relationships is lower than Project A's, and a major gap is evident. It can be said that good interpersonal relationships are continuing to be maintained among requirements definition stakeholders in Project A, and that the possibility of building good interpersonal relationships in the future in Project B is low.

8.2. Shift in stabilization potential due to destabilizing factors

According to the scale of destabilizing factors, we compared the shifts due to destabilizing factors and stabilizing potential of both actual requirements definition projects(Fig.4).

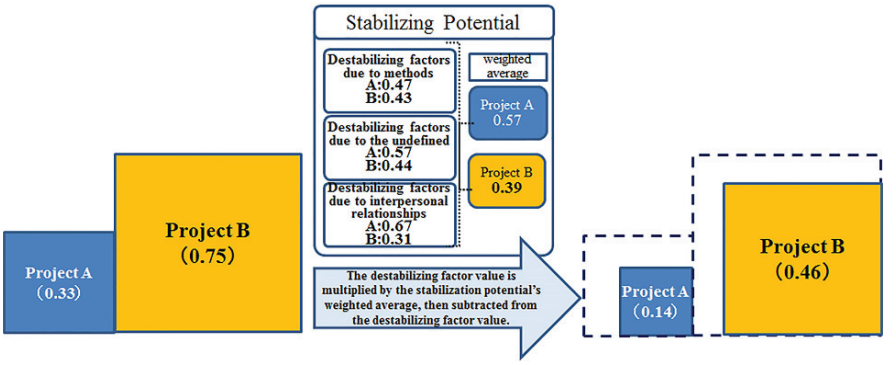

Fig.4. Comparison of the scale of destabilizing factors with projects' stabilizing potential taken into account

With regards to Project B, which began with large destabilizing factors, stabilizing potential is low, there is a trend towards low reductions in destabilizing factors, and it can be said that it is on a path where instability will not be eliminated. Project A, where destabilizing factors are small, is on a path where stabilizing potential is high, and a tendency towards large reductions in destabilizing factors—namely, a tendency toward stabilization—can be said to be visible.

8.3. Observations regarding stabilizing factors and the success or failure of projects

Failed projects especially have large destabilizing factors due to interpersonal relationships, and it is suspected that the appropriate stabilization potential is also insufficient. Destabilizing factors due to the undefined and destabilizing factors related to methods are surmised to exist in similar proportions regardless of projects' chances of success, and it is suspected that the related stabilization potential also exists in similar proportions.

It can be predicted from this that differences in destabilizing factors and stabilizing potential of interpersonal relationships determines the success or failure of a project. In other words, we can say that it can be recognized that ITSC requirements definition projects' destabilizing factors and stabilizing potential factors are in a cause and effect

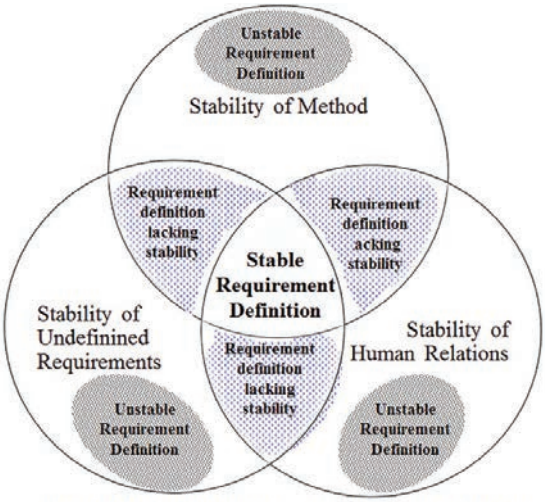

Fig. 5: Stabilized structure model in requirement definition

relationship with the success or failure of a project.

9. Conclusion

Regarding the stability of the requirement definition process in IT system building projects, we succeeded in formulating a model for instability factors and stability possibilities to counter them (Fig.5).

Based on multiple examples of actual IT system building projects, we were able to clarify the causal relationship between the success or failure of projects and stabilization models from a QCD perspective. Moreover, based on model authentication using cases of modeling requirement definition instability factors/stability possibility, the stability of requirement definition is presumed to be based on three factors, namely (1) the stability of the requirement definition method, (2)the stability of undefined requirements and (3) the stability of human relations (stakeholders). The requirement definition where all three stability factors overlap is stable. Where all three do not overlap, stability is lacking or the requirement definition is unstable and we think that this model building of stabilization is also applicable to other management.

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